

OPTIMIZATION OF MICROELECTRONIC DEVICES FOR SENSOR APPLICATIONS

Tom Cwik and Gerhard Klimeck
Jet Propulsion Laboratory
California Institute of Technology
4800 Oak Grove Dr.
Pasadena Ca, 91109
818-354-4386
818-393-3134 FAX
cwik@jpl.nasa.gov

The NASA/JPL goal to reduce payload in future space missions while increasing mission capability demands miniaturization of active and passive sensors, analytical instruments and communication systems among others. Currently, typical system requirements include the detection of particular spectral lines, associated data processing, and communication of the acquired data to other systems. Advances in lithography and deposition methods result in more advanced devices for space application, while the sub-micron resolution currently available opens a vast design space. Though an experimental exploration of this widening design space—searching for optimized performance by repeated fabrication efforts—is unfeasible, it does motivate the development of reliable software design tools. These tools necessitate models based on fundamental physics and mathematics of the device to accurately model effects such as diffraction and scattering in opto-electronic devices, or bandstructure and scattering in heterostructure devices. The software tools must have convenient turn-around times and interfaces that allow effective usage. The first issue is addressed by the application of high-performance computers and the second by the development of graphical user interfaces driven by properly developed data structures. These tools can then be integrated into an optimization environment, and with the available memory capacity and computational speed of high performance parallel platforms, simulation of optimized components can proceed. In this paper, specific applications of the electromagnetic modeling of infrared filtering, as well as heterostructure device design will be presented using genetic algorithm global optimization methods.

The specific global optimization package used is PGAPACK (Levine G., *Users Guide to the PGAPACK Parallel Genetic Algorithm Library*, Argonne Nat. Lab., 95/18, 1996). This library has been ported to the JPL HP Exemplar 256 CPU parallel computer. PGAPACK is used to synthesize a design for a micromachined infrared filter consisting of an aperture in a gold layer deposited on a calcium fluoride substrate (Ksendzov, A., Fernandez, S., Cwik, T., La Baw, C. Maker, P. and Muller R., "Wedge Filters for Spectral Imaging in the Near IR Using Metal Grids, *Proceedings Infrared Astronomical Instrumentation*. Vol 3354, 1998). The filter is to be used as a component in a imaging spectrometer, and requires a specified center wavelength and specified narrow bandwidth. These specifications are used to derive a fitness function that the genetic algorithm attempts to minimize. The filter response for a given micromachined grid geometry is modeled using frequency selective surface design software that solves Maxwell's equations with the appropriate boundary conditions (Cwik T. and Mitra R., "Scattering from a periodic array of free-standing arbitrarily shaped perfectly conducting or resistive patches", *IEEE Trans. Antennas Propag.*, vol. AP-35, no. 11, pp. 1226-1233, Nov. 1987). Results for ~~the~~ both the synthesized design and the genetic algorithm optimization process will be presented.